Mechanical Property Standards

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The goal of this research is to develop standard mechanical test methods and standard reference materials in support of national and international standardization programs. This work encompasses a variety of activities including conducting prestandardization research, performing round robins, writing standards and practices, and creating standard reference materials.

The goal of this project is to develop procedures that are as technically rigorous as possible yet are practical and useable by industry. Current work is targeted towards fracture toughness, hardness, diametral compression strength, fractographic analysis, and flexure strength of cylindrical specimens. Standard practices or test methods are prepared so that accurate and precise mechanical property data results can be obtained by NIST, industry, government, and academia. VAMAS round robin projects are conducted as necessary to verify test method maturity.

The output of this project has been a series of ASTM test method standards and practices, complimentary Standard Reference Materials where needed, NIST practices, and ISO standards. Ten ASTM, one MIL STD, and two ISO standards and two Standard Reference Materials (Knoop hardness and fracture toughness) have been created in this program. Five international round robins have been organized and completed. Work is underway on several new ASTM and ISO standards and one SRM (Vickers hardness).

Now that refined and standardized test methods are available, data quality has improved dramatically, both for routine characterization and for design purposes. It is easy to compare data between laboratories whereas in the recent past, chaos reigned and ceramic data credibility suffered. Standards also convert research procedures into mature engineering practices. For example, ASTM C1322 for fractographic analysis codified and demystified what heretofore had been a highly interpretive "black art."

Besides creating a series of individual standards, this program is contributing to building a national and international standards infrastructure. The individual standards are interrelated and may be used together. For example, the fracture toughness, slow crack growth-dynamic fatigue, elastic modulus, and ceramic machining methods all utilize the versatile flexural strength standard, ASTM C1161. The same specimens, fixtures, and loading configurations are used. Furthermore, the individual standards may be used as building blocks in various combinations. For example, for design applications, a strength test standard may be used to accumulate raw data, a standard fractographic analysis used to interpret the cause of fracture, and a statistical analysis standard applied for data reduction and analysis. This interrelated infrastructure supports data bases, design codes and practices, and materials specifications.

The value and impact of this project is growing throughout the advanced ceramics industry. The test methods are sufficiently generic and universal that they may be applied to heat engine, armor, biological, and electronic ceramic materials. For example, a new silicon nitride bearing ball material specification standard, being created in ASTM Committee F-34 with very active European and Japanese participation, utilizes <u>five standards</u> developed in this NIST program. Three ceramic biological material specifications created by ASTM Committee F-04, with very active European participation, include <u>four of the same standards</u> created by this NIST program. Significant cost savings can now be directly attributed to the adoption of several of the standards. Promulgation of a new advanced technique (elastic moduli by impact resonance) has been significantly enhanced by standardization.

This year we completed two ISO standard test methods (room temperature flexural strength and hardness), contributed to the adoption of a third (fracture toughness by single-edged precracked beam), and advanced two others (elevated temperature flexural strength and fracture toughness by the surface crack in flexure method). A major effort on fractographic characterization of strength-limiting flaws in cylindrical rod and rectangular bar flexural strength specimens was completed. This work contributes to four ASTM standards: revision to C 1322, the master fractographic analysis standard; revision to C1161, the master flexural strength standard, a new standard on evaluating the effects of machining upon ceramic strength; and a new standard test method for flexural strength testing of rods.

We also analyzed and wrote a paper on the effect of chamfers on bend bar resonance for elastic moduli determination in cooperation with Mr. Jeff Swab of the U. S. Army Research Laboratory. The paper will be used as the basis for a revision to 2 ASTM standards that use this method to measure elastic modulus. A series of presentations and publications on the new ASTM and ISO fracture toughness standards as well as the new NIST Standard Reference Material 2100 for fracture toughness were made. SRM 2100 is the world's first reference material for fracture toughness for any class material. We also cooperated with a European round robin on ceramic hardness organized by BAM, Berlin. BAM utilized NIST SRM 2830 Knoop hardness and prototype SRM 2831 Vickers hardness blocks and compared their performance to alternatives. The NIST SRM's were the best in the entire exercise.

Contributors and Collaborators

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